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Table 4

TRANSMISSIVITIES CALCULATED FROM SPECIFIC-CAPACITY & PUMP TEST DATA

Well Name/Description		Map No. on	Total	Transmissivity for Upper	Transmissivity for
City of San Bernardino, Newmark #1	1N4W16E01S	101	40,364	37,900	2,500
City of San Bernardino, Newmark #2	1N4W16E	100	32,837	30,800	2,000
City of San Bernardino, Newmark #2	4N4W16E03S	102	28,184	26,500	1,700
City of San Bernardino, Newmark #4	1N4W16E	3	35,898	33,700	2,200
City of San Bernardino, 16th Street	1N4W34G03S	28	23,157 to 34,388[a]	NS	23,200 to 34,400
City of San Bernardino, Leroy	1N4W27A	12	38,051	NS	38,000
City of San Bernardino, 30th Street & Mt. View (Marshall)	1N4W27G01S	15	35,217	35,200	NS
City of San Bernardino, 24st Street & Mt. View	1N4W27B	14	35,965 to 53,346[a]	36,000 to 53,300	NS
City of San Bernardino, 27th Street	1N4W27M02S	17	32,115 to 48,359[a]	13,000 to 19,500	13,500 to 20,400
City of San Bernardino, 23rd Street	1N4W27N01S	18	24,039 to 49,121[a]	NS	24,000 to 49,100
City of San Bernardino, North "E" Street	1N4W27M01S	16	2928 to 50,218[a]	NS	3000 to 50,200
City of San Bernardino, 19th Street #1	1N4W42D03S	24	55,530 to 71,556[a]	40,500 to 52,200	15,000 to 19,300
City of San Bernardino, 19th Street #2	1N4W32D04S	25	24,286 to 54,175[a]	22,500 to 39,000	8800 to 15,200
City of San Bernardino, Waterman Avenue	1N4W27A01S	13	62,277 to 76,864[a]	24,800 to 39,200	30,500 to 39,200
City of San Bernardino, Gilbert Street	1N4W35M03S	34	29,922 to 23,638[a]	NS	29,900 to 23,700
City of San Bernardino, 7th Street	1S4W03J	46	42,730 to 44,790[a]	NS	42,700 to 44,800
City of San Bernardino, Perris Hill #4	1N4W35C03S	24	9,680	9,700	NS
City of San Bernardino, Perris Hill #5	1N4W26P02	426	11,088 to 20,296[a]	11,100 to 20,300	NS
City of San Bernardino, Lynwood	1N4W26G	8	22,515	NS	22,500
City of San Bernardino, 9th & Perris	1S4W04G	129	23,524 to 30,484[a]	19,500 to 25,300	4000 to 5200
San Bernardino Valley Municipal Water Dist., 9th & Garner	1S4W04F	130	33,826 to 36,901[a]	28,000 to 30,600	5800 to 12,500
City of San Bernardino, 10th & J	1S4W04B04	124	45,191 to 112,977[a]	37,500 to 93,700	7700 to 19,300
City of San Bernardino, Olive & Garner	1S4W04C	132	9,626 to 10,028[a]	8,000 to 8,300	1,600 to 1,700

[a] Range of values calculated from two to three sets of data.
[b] Units in ft^2/day
NS = Well is not screened in this aquifer.

Appendix J

Table 5

WELL PUMPAGE
(AVERAGE FOR 1982 - 1986)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Pumpage (ft^3/day)
City of Riverside, Poole	1S4W01E01S	303601462	1	0.0
East San Bernardino County Water District., #22	1S4W01E02S	303601668	2	0.0
City of San Bernardino, Newmark #4	1N4W16E	303602399	2	410,725.9
Arrowhead Country Club #1	1N4W23E	303601810	4	53,704.1
Del Rosa Mutual Water Co. Parkside #2	1N4W23E	303601925	5	0.0
E. San Bernardino County Water District, #24B	1N4W26A	303602337	6	175,246.6
E. San Bernardino County Water District, #24A	1N4W26A02S	303601671	7	56,281.9
City of San Bernardino, Lynwood	1N4W26G	303600727	8	113,709.5
City of San Bernardino, Perris Hill #5	1N4W26P03S	303601115	9	53,465.4
City of San Bernardino, Mt. View Cemetary #1	1N4W26	Unknown	10	12,483.2
City of San Bernardino, Mt. View Cemetary #2	1N4W26	Unknown	11	9,093.9
City of San Bernardino, Leroy	1N4W27A	303602401	12	50,744.4
City of San Bernardino, Waterman Avenue	1N4W27A01S	303600728	12	424,116.2
24st Street & Mt. View	1N4W27B	303602081	14	85,824.1
City of San Bernardino, 30th Street & Mt. View (Marshall)	1N4W27G01S	303600719	15	67,046.6
City of San Bernardino, North "E" Street	1N4W27M01S	303600727	16	17,638.8
City of San Bernardino, 27th Street	1N4W27M02S	303601671	17	35,683.4
City of San Bernardino, 23rd Street	1N4W27N01S	303602264	18	6,038.7
City of San Bernardino, Darby	1N4W29E01S	303601878	19	4,033.8
City of San Bernardino, Colima	1N4W29F01S	303601880	20	9,571.3
City of San Bernardino, Gardena	1N4W29	303601879	21	6,921.9
Mt. Vernon Water Company, #1	1N4W24A01S	303600249	22	29,787.9
Southern California Water Company, Berdoo #1	1N4W24H	303601588	22	40,979.5
City of San Bernardino, 19th Street #1	1N4W32D03S	303600717	24	103,111.9
City of San Bernardino, 19th Street #2	1N4W32D04S	303600718	25	80,699.4
City of San Bernardino, Baseline	1N4W32N	303602400	26	36,113.0

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Table 5 (Cont'd.)

WELL PUMPAGE
(AVERAGE FOR 1982- 1986)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Pumpage (ft^3/day)
City of San Bernardino, 17th Street	1N4W34G01S	303600725	27	28,379.6
City of San Bernardino, 16th Street	1N4W34G03S	303600726	28	91,941.4
City of San Bernardino, Perris Hill #2	1N4W35C01S	303601114	29	0.0
City of San Bernardino, Perris Hill #2	4N4W35C02S	303601116	30	8,902.9
City of San Bernardino, Perris Hill #4	1N4W35C03S	303601117	24	29,549.2
Baseline Gardena Mutual Water Company, Pac & Barl	1N4W35J02S	303600457	32	0.0
Van Loon Mutual Water Company, W3-Gilbert	1N4W35K	303602067	32	45,156.5
City of San Bernardino, Gilbert Street	1N4W35M03S	303600729	34	147,936.9
Baseline Gardens Mutual Water Company, PS & B2	1N4W36M01S	303600458	35	9,547.4
City of Riverside, Stiles	1N4W02B	303601463	36	218,349.0
Van Loon Mutual Water Company, #1	1S4W02B	303602066	37	47.7
City of San Bernardino, Antil #5	1S4W02K02S	303600724	38	158,152.6
City of San Bernardino, Antil #4	1S4W02K03S	303600734	39	81,868.9
City of San Bernardino, Antil #6	1S4W02K08S	303602422	40	455,649.5
City of Riverside, Scheuer	1S4W02601S	303601489	41	35,086.7
City of Riverside, Garner #5	1S4W02P01S	303601468	42	191,902.7
City of Riverside, Garner #1	1S4W02P06S	303601464	43	84,661.5
City of Riverside, Garner #2	1S4W02Q03S	303601465	44	36,208.5
City of Riverside, Garner #4	1S4W02Q06S	303601467	45	64,826.8
City of San Bernardino, 7th Street	1S4W03J	303602265	46	359,197.0
West San Bernardino Water District, Plant #15	1S4W05E05S	303601848	47	167,795.5
City of Colton, #8	1S4W08F	303601254	48	96,762.9
City of Colton, #12	4S4W08F	303601257	49	117,647.8
City of Colton, #19	1S4W08F	303602405	50	36,781.3
Terrace Water Company, #2	4S4W08F	303601686	51	18,856.1
City of Colton, #16	1S4W08F01S	303601260	52	94,113.5
Terrace Water Company, Large #1	1S4W08F06S	303601684	53	61,533.0
City of Colton, #5	1S4W08R	303601251	54	73,037.6
City of Colton, #7	1S4W08R	303601253	55	68,884.5

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Table 5 (Cont'd.)

WELL PUMPAGE
(AVERAGE FOR 1982- 1986)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Pumpage (ft^3/day)
City of Colton, #14	1S4W08R	303601258	56	40,552.6
Ice Products, Inc., #2	1S4W09B03S	303600970	57	644.4
City of Riverside, Cooley H	1S4W11D02S	303601228	58	127,386.1
City of Riverside, Cooley I	1S4W11D03S	303601229	59	344,279.1
Cardiff Farms Mutual Water Company, #1	1S4W12D	303600973	60	23,582.1
Cardiff Farms Mutual Water Company	1S4W12D	303601619	61	15,729.3
City of Riverside - Gage Canal, #29-2	1S4W13N01S	303600791	62	426,004.9
City of Riverside - Gage Canal, #29-2	4S4W13N02S	303600792	63	387,600.5
San Bernardino County Water District, Norman Rd.	1S4W14J	303602123	64	6,181.9
City of Riverside, Raub #2	4S4W14P06S	303601239	65	36,327.8
National Orange Show	1S4W15D	303601924	66	6,921.9
Meeks & Daley Water Company, #59	1S4W15L03S	303601887	67	290,718.2
Meeks & Daley Water Company, New "E" Street	1S4W15M10S	303602169	68	208,085.5
Meeks & Daley Water Company, Coburn	1S4W16J09S	303601737	69	19,452.8
City of Riverside, Thorn #10	1S4W22B03S	303601478	70	6,921.9
City of Riverside, Thorn #2	4S4W22G14S	303601471	71	32,962.4
City of Riverside, Thorn #2	1S4W22G15S	303601470	72	98,338.2
City of Riverside, Thorn #5	1S4W22G16S	303601473	72	43,056.1
City of Riverside, Thorn #7	1S4W22G17S	303601475	74	7,900.5
City of Riverside, Thorn #6	1S4W22G18S	303601474	75	7,518.6
City of Riverside, Warren #2	1S4W22H01S	303601224	76	91,583.4
City of Riverside, Warren #4	1S4W22H02S	303601234	77	169,546.9
City of Riverside, Warren #2	4S4W22H03S	303601230	78	11,624.0
City of Riverside, Warren #1	1S4W22H04S	303601240	79	76,498.5
Riverside Highland Water Company, #2	1S4W22L00S	303601523	80	97,073.2
Riverside Highland Water Company, #18	1S4W22L05S	303601533	81	82,036.0
Riverside Highland Water Company #12	1S4W22L08S	303601530	82	21,529.4

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Table 5 (Cont'd.)

WELL PUMPAGE
(AVERAGE FOR 1982- 1986)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Pumpage (ft^3/day)
Riverside Highland Water Company, #24	1S4W22P05	303602254	83	4,749.8
City of Riverside - Gage Canal #26-1	1S4W23A02S	303600787	84	205,197.4
City of Riverside - Gage Canal #51-1	1S4W23A05S	303600796	85	123,113.7
City of Riverside, Raub #2	1S4W23C02S	303601219	86	19,476.7
City of Riverside, Raub #4	1S4W23C03S	303601238	87	193,000.6
Meadowbrook Diary, Irrig #2	4S4W23D	303600030	88	46,519.7
City of Riverside - Gage Canal #66-1	1S4W23G	303602324	89	408,986.6
City of Riverside - Gage Canal #27-1	1S4W23H01S	303600788	90	227,228.1
City of Riverside - Gage Canal #27-2	1S4W23K01S	303600789	91	203,932.4
City of Riverside - Gage Canal #29-1	1S4W23K02S	303600790	92	205,340.6
Loma Linda University, #7	1S4W24N	30360213	93	0.0
Montecito Mutual Water Company, #1	1S4W26F01	303600119	94	18,951.6
City of Riverside, Hunt #11	1S4W27A01S	303601245	95	763.8
City of Riverside, Hunt #10	1S4W27A09S	303601244	96	453.5
City of Riverside, Hunt #6	1S4W27A11S	303601222	97	787.7
City of San Bernardino, Devil Canyon #2	1N4W07F01S	243600711	98	43,034.9
City of San Bernardino, Devil Canyon #1	1N4W08M01S	243600712	99	108,100.4
City of San Bernardino, Newmark #2	1N4W16E	243600715	100	119,461.8
City of San Bernardino, Newmark #1	1N4W16E01S	243600714	101	70,173.4
City of San Bernardino, Newmark #2	4N4W16E03S	243600716	102	42,843.9
Baseline Gardens Mutual Water Company, #2	4N4W35R01S	303602528	102	42,650.3
City of Colton, #6B	1S4W08R07S	303602498	104A	6,754,8
William E. Leomard, H. Payne	1S4W22A01S	303602499	104B	27,782.9
City of Riverside, Raub #5	1S4W14N09S	303602484	105	404,069.7
Riverside Highland Water Company, Lytle Creek #1	1N4W24E01S	333601535	106	95,115.9

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Table 5 (Cont'd.)

WELL PUMPAGE
(AVERAGE FOR 1982- 1986)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Pumpage (ft^3/day)
City of San Bernardino, Mallory #2	4N4W30L	333601845	107A	11,289.8
City of Colton, #21	1S4W08F15S	303602792	407B	257,015.9
Loma Linda University, Anderson #1	1S4W25D07S	303602855	108	5,298.8
East Valley Water District, PL 11A	1S4W02Q10S	303602562	409	6,062.6
San Bernardino Golf Club, Kline	1S4W22A01S	303602846	110	5,298.8
Loma Linda University, Anderson #2	1S4W25D06S	303602781	111	71,701.0
City of Riverside, Raub #6	1S4W14N10S	303602484	112	441,781.9
City of Riverside, Hunt #11	1S4W27A10S	30602772	413	65,733.8
Meeks & Daley Water Company, Warren #4	1S4W22H01S	303602862	414	907.0
Meeks & Daley Water Company, Raub #6	1S4W14N10S	303602864	115	15,944.2
City of Riverside, Hunt #10	1S4W27A09S	303602772	116	114,115.3
City of Riverside, Hunt #6	1S4W27A11S	303602771	117	57,666.3
West San Bernardino Water District., #30	1S4W06H02S	303602766	118	111,466.9
City of San Bernardino, Ice Deliver #1	1S4W09B01S	303600645	119	0.0
City of San Bernardino, Antil #2	1S4W02K05	303600732	120	0.0
City of San Bernardino, Antil #2	4S4W02K01	303600730	121	0.0
City of San Bernardino, Hanford #2	1S4W10F05	303600724	122	0.0
City of San Bernardino, A. Ree	1S4W11K01	—	123	0.0
City of San Bernardino, Mill & "D" Street	1S4W10N06	303600737	124	0.0
City of San Bernardino, South "G" Street	1S4W09J01S	303600736	125	0.0
City of San Bernardino, Perris Hill #5	1N4W26P03	303601115	126	0.0
Nevada California Power Company, #2	1S4W21Q3	—	127	0.0
Riverside Water Company, Vaughn #1	1S4W21Q3	—	128	0.0
City of San Bernardino, 9th & Perris	1S4W04G	—	129	New
San Bernardino Valley Municipal Water District, 9th & Garner	1S4W04F	—	130	New
City of San Bernardino, 10th & J	1S4W04B04	—	124	New

Appendix J

Table 5 (Cont'd.)

WELL PUMPAGE
(AVERAGE FOR 1982- 1986)

Well Name/Description	State Well Location	Local Description	Map No. On Figure 14	Pumpage (ft^3/day)
City of San Bernardino, Olive & Garner	1S4W04C	—	132	New

New = Wells did not exist before 1986.
Source = Western Watermaster

Since the model area is represented by two layers, pumpage for each layer was estimated by well depth, location, and length of perforations. Pumpage was assigned to the upper model layer for wells perforated only in the upper aquifer. Pumpage for wells perforated only in the lower aquifer was assigned to the lower model layer. Pumpage from wells perforated in both aquifers was prorated, depending on the length of perforations in each aquifer system. The prorated discharge from these wells was allocated to the nearest nodes. As many as seven wells were grouped together to represent the composite pumpage for one model cell. The input data for well pumpage for each model cell are contained in the Well (WEL) input files (*RUN.WEL*).

1.5.7 VERTICAL LEAKANCE VALUES

In order to represent the hydrologic connection between the two layers of the model, vertical leakance values were estimated for the middle confining clay unit that separates the upper and lower aquifer. Leakance is the ratio of the vertical hydraulic conductivity of the clay material to the thickness of the middle confining clay unit. In other words, leakance is used to quantify the rate at which water moves vertically through a particular clay unit into the aquifer. Within the model area, some downward movement of groundwater from the upper aquifer occurs through the middle confining clay unit to the lower aquifer.

A vertical hydraulic conductivity of 10^{-8} cm/sec (2.83×10^{-5} ft/day) was assumed for the middle confining clay unit (Freeze and Cherry, 1979) and the thicknesses of the middle confining clay unit ranged from 30 to nearly 300 feet south of Shandin Hills. A thickness of one foot was assumed for the middle confining clay unit adjacent and north of Shandin Hills. The resultant leakance values for the middle confining clay unit ranged from 9.43×10^{-7} to 1.00×10^{-7} (ft/day)/ft (Table 1).

Many wells in the model area were not constructed below the upper aquifer and did not contain any information concerning the middle confining clay unit. The vertical leakance values for the middle confining clay unit are contained in the Block-centered Flow input file (*RUN.BCF*).

1.6 STATUS OF STEADY-STATE MODEL

As of October 1991, the preliminary steady-state model is undergoing calibration. The calibration process has consisted of seven major grouped runs with each run containing two to five individual modifications. A total of 29 calibration runs have been performed. The nomenclature for the input and output files is arranged in the following format:

- The filename for the input or output file contains a rootname and an extension. For example, the filename *RUN.OUT* contains a rootname of *RUN* and an extension of *OUT*.

- The rootname for every input and output file is named according to the run number, modification letter, and date (month and day) the file was produced. For example, an output file produced from the first run, the first modification, and on April 11 would have the filename *1A0411.OUT*.

- Some output files are a record of the calculated cell-by-cell flows of several input packages. The rootnames (e.g., *3ACELL.BCF*) for these files are designated by the run number and modification followed by *CELL*.

- The extensions for all filenames are abbreviations of the input packages used in MODFLOW (*BCF, BAS, WEL*, etc.) or the abbreviation *OUT* for output file.

- The abbreviated extensions for the input packages used in MODFLOW consist of *BAS* for Basic, *BCF* for Block-Centered Flow, *OC* for Output Control, *SIP* for Strongly-Implicit Procedure, *STR* for Streamflow Routing, *WEL* for Well, *RIV* for River, and *GHB* for General-head Boundary.

Table 6 contains a listing of all the input and output files that have been produced during the preliminary steady-state calibration process. A brief summary of the revisions and results for the computer runs are presented in Table 7. Runs *3C0507*, *3D0508* and *3E0508* consist of a brief capture-zone analyses of the downgradient plume area. Ten extraction wells were placed at the downgradient edge of the plume. The wells were located in cells (36,27), (37,28), (38,29), (39,30), (39,31), (39,32), (39,33), (38,34), (37,35) and (36,36).

The original input files have undergone a series of changes during the calibration process of the preliminary steady-state model. The first set of changes was made to the original input data files to eliminate dry cells and the failure of the model to converge. Most of these errors, such as dry cells and failure of the model to converge, were eliminated in *RUN 1*.

As part of the calibration process, the assigned boundary conditions were tested for evaluating their effects on the overall groundwater flow patterns for the model area. For example, the boundary conditions for the eastern and western boundaries of the model area were modified using constant-head conditions and constant-flow conditions. At the present time, constant-head conditions are being used for the eastern and western boundaries of the model area, except for the cells where the streams enter the model area. These cells are represented by the General-head Boundary package. Furthermore, the Streamflow routing package has been replaced with the River package to represent the streamflow interactions with the aquifer system. Also, the lateral area effected by the stream alluvium has been widened. To further update surface water interaction with the aquifer system, all percolation basins have been modified so that inflowing surface water recharges the groundwater below.

Hydraulic conductivity and transmissivity values have been adjusted during the calibration period to minimize the difference between computed and observed heads. Hydraulic conductivity and transmissivity values have been tested in the model for evaluating their effects on localized water elevation fluctuations and overall groundwater flow patterns for the model area. Several versions of the initial set of hydraulic conductivities and transmissivities defined in Section 1.5.5 were used in the calibration runs. Also, hydraulic conductivities and transmissivities used in the groundwater modeling study conducted by Hardt and Hutchinson (1980) have been used in the project flow model.

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Table 6

INPUT AND OUTPUT FILENAMES

Run Number	Rootname Modification	Date	Cell-by-Cell Flow File	Extension	Filename
1	A	04/11/91		BAS	1A0411.BAS
1	A	04/11/91		BCF	1A0411 BCF
1	A	04/11/91		OC	1A0411.OC
1	A	04/11/91		SIP	1A0411.SIP
1	A	04/11/91		STR	1A0411.STR
1	A	04/11/91		WEL	1A0411 WEL
1	A	04/11/91		OUT	1A0411.OUT
1	B	04/12/91		BAS	1B0412.BAS
1	B	04/12/91		BCF	1B0412.BCF
1	B	04/12/91		OC	1B0412 OC
1	B	04/12/91		SIP	1B0412.SIP
1	B	04/12/91		STR	1B0412.STR
1	B	04/12/91		WEL	1B0412.WEL
1	B	04/12/91		OUT	1B0412 OUT
1	C	04/16/91		BAS	1C0416.BAS
1	C	04/16/91		BCF	1C0416.BCF
1	C	04/16/91		OC	1C0416.OC
1	C	04/16/91		SIP	1C0416.SIP
1	C	04/16/91		STR	1C0416.STR
1	C	04/16/91		WEL	1C0416.WEL
1	C	04/16/91		OUT	1C0416.OUT
1	D	04/17/91		BAS	1D0417 BAS
1	D	04/17/91		BCF	1D0417 BCF
1	D	04/17/91		OC	1D0417.OC
1	D	04/17/91		SIP	1D0417 SIP
1	D	04/17/91		STR	1D0417.STR
1	D	04/17/91		WEL	1D0417.WEL
1	D	04/17/91		OUT	1D0417.OUT
2	A	04/22/91		BAS	2A0422.BAS
2	A	04/22/91		BCF	2A0422.BCF
2	A	04/22/91		OC	2A0422.OC

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Table 6 (Cont'd.)

INPUT AND OUTPUT FILENAMES

Run Number	Rootname Modification	Date	Cell-by-Cell Flow File	Extension	Filename
2	A	04/22/91		SIP	2A0422.SIP
2	A	04/22/91		STR	2A0422.STR
2	A	04/22/91		WEL	2A0422.WEL
2	A	04/22/91		OUT	2A0422.OUT
2	B	04/23/91		BAS	2B0423.BAS
2	B	04/23/91		BCF	2B0423.BCF
2	B	04/23/91		OC	2B0423.OC
2	B	04/23/91		SIP	2B0423.SIP
2	B	04/23/91		STR	2B0423.STR
2	B	04/23/91		WEL	2B0423.WEL
2	B	04/23/91		OUT	2B0423.OUT
2	C	04/24/91		BAS	2C0424.BAS
2	C	04/24/91		BCF	2C0424.BCF
2	C	04/24/91		OC	2C0424.OC
2	C	04/24/91		SIP	2C0424.SIP
2	C	04/24/91		STR	2C0424.STR
2	C	04/24/91		WEL	2C0424.WEL
2	C	04/24/91		OUT	2C0424.OUT
2	D	04/24/91		BAS	2D0424.BAS
2	D	04/24/91		BCF	2D0424.BCF
2	D	04/24/91		OC	2D0424.OC
2	D	04/24/91		SIP	2D0424.SIP
2	D	04/24/91		STR	2D0424.STR
2	D	04/24/91		WEL	2D0424.WEL
2	D	04/24/91		OUT	2D0424.OUT
2	E	04/25/91		BAS	2E0425.BAS
2	E	04/25/91		BCF	2E0425.BCF
2	E	04/25/91		OC	2E0425.OC
2	E	04/25/91		SIP	2E0425.SIP
2	E	04/25/91		STR	2E0425.STR

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Table 6 (Cont'd.)

INPUT AND OUTPUT FILENAMES

Run Number	Rootname Modification	Date	Cell-by-Cell Flow File	Extension	Filename
2	E	04/25/91		WEL	2E0425.WEL
2	E	04/25/91		OUT	2E0425 OUT
3	A	04/25/91		BAS	3A0425.BAS
3	A	04/25/91		BCF	3A0425.BCF
3	A	04/25/91		OC	3A0425.OC
3	A	04/25/91		SIP	3A0425.SIP
3	A	04/25/91		STR	3A0425.STR
3	A	04/25/91		WEL	3A0425.WEL
3	A	04/25/91	✓	BCF	3ACELL.BCF
3	A	04/25/91	✓	STR	3ACELL.STR
3	A	04/25/91	✓	WEL	3ACELL.WEL
3	A	04/25/91		OUT	3A042.OUT
3	B	05/02/91		BAS	3B0502.BAS
3	B	05/02/91		BCF	3B0502 BCF
3	B	05/02/91		OC	3B0502.OC
3	B	05/02/91		SIP	3B0502 SIP
3	B	05/02/91		STR	3B0502.STR
3	B	05/02/91		WEL	3B0502.WEL
3	B	05/02/91		GHB	3B0502.GHB
3	B	05/02/91	✓	BCF	3BCELL.BCF
3	B	05/02/91	✓	STR	3BCELL.STR
3	B	05/02/91	✓	WEL	3BCELL.WEL
3	B	05/02/91	✓	GHB	3BCELL.GHB
3	B	05/02/91		OUT	3B0502.OUT
3	C	05/07/91		BAS	3C0507.BAS
3	C	05/07/91		BCF	3C0507.BCF
3	C	05/07/91		OC	3C0507.OC
3	C	05/07/91		SIP	3C0507.SIP
3	C	05/07/91		STR	3C0507.STR
3	C	05/07/91		WEL	3C0507.WEL
3	C	05/07/91	✓	BCF	3CCELL.BCF

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Table 6 (Cont'd.)

INPUT AND OUTPUT FILENAMES

Run Number	Rootname Modification	Date	Cell-by-Cell Flow File	Extension	Filename
3	C	05/07/91	✓	STR	3CCELL.STR
3	C	05/07/91	✓	WEL	3CCELL.WEL
3	C	05/07/91		OUT	3C0507.OUT
3	D	05/08/91		BAS	3D0508.BAS
3	D	05/08/91		BCF	3D0508.BCF
3	D	05/08/91		OC	3D0508.OC
3	D	05/08/91		SIP	3D0508.SIP
3	D	05/08/91		STR	3D0508.STR
3	D	05/08/91		WEL	3D0508.WEL
3	D	05/08/91	✓	BCF	3DCELL.BCF
3	D	05/08/91	✓	STR	3DCELL.STR
3	D	05/08/91	✓	WEL	3DCELL.WEL
3	D	05/08/91		OUT	3D0508.OUT
3	E	05/08/91		BAS	3E0508.BAS
3	E	05/08/91		BCF	3E0508.BCF
3	E	05/08/91		OC	3E0508.OC
3	E	05/08/91		SIP	3E0508.SIP
3	E	05/08/91		STR	3E0508 STR
3	E	05/08/91		WEL	3E0508.WEL
3	E	05/08/91	✓	BCF	3ECELL.BCF
3	E	05/08/91	✓	STR	3ECELL.STR
3	E	05/08/91	✓	WEL	3ECELL.WEL
3	E	05/08/91		OUT	3E0508.OUT
4	A	05/21/91		BAS	4A0521.BAS
4	A	05/21/91		BCF	4A0521.BCF
4	A	05/21/91		OC	4A0521.OC
4	A	05/21/91		SIP	4A0521.SIP
4	A	05/21/91		STR	4A0521.STR
4	A	05/21/91		WEL	4A0521.WEL
4	A	05/21/91	✓	BCF	4ACELL.BCF
4	A	05/21/91	✓	STR	4ACELL STR

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Table 6 (Cont'd.)

INPUT AND OUTPUT FILENAMES

Run Number	Rootname Modification	Date	Cell-by-Cell Flow File	Extension	Filename
4	A	05/21/91	✓	WEL	4ACELL.WEL
4	A	05/21/91		OUT	4ACELL.OUT
4	B	05/22/91		BAS	4B0522.BAS
4	B	05/22/91		BCF	4B0522.BCF
4	B	05/22/91		OC	4B0522.OC
4	B	05/22/91		SIP	4B0522.SIP
4	B	05/22/91		STR	4B0522.STR
4	B	05/22/91		WEL	4B0522.WEL
4	B	05/22/91	✓	BCF	4BCELL.BCF
4	B	05/22/91	✓	STR	4BCELL.STR
4	B	05/22/91	✓	WEL	4BCELL.WEL
4	B	05/22/91		OUT	4B0522.OUT
4	C	05/23/91		BAS	4C0523.BAS
4	C	05/23/91		BCF	4C0523.BCF
4	C	05/23/91		OC	4C0523.OC
4	C	05/23/91		SIP	4C0523.SIP
4	C	05/23/91		STR	4C0523.STR
4	C	05/23/91		WEL	4C0523.WEL
4	C	05/23/91	✓	BCF	4CCELL.BCF
4	C	05/23/91	✓	STR	4CCELL.STR
4	C	05/23/91	✓	WEL	4CCELL.WEL
4	C	05/23/91		OUT	4C0523.OUT
4	D	05/23/91		BAS	4D0523.BAS
4	D	05/23/91		BCF	4D0523.BCF
4	D	05/23/91		OC	4D0523.OC
4	D	05/23/91		SIP	4D0523.SIP
4	D	05/23/91		STR	4D0523.STR
4	D	05/23/91		WEL	4D0523.WEL
4	D	05/23/91	✓	BCF	4DCELL.BCF
4	D	05/23/91	✓	STR	4DCELL.STR
4	D	05/23/91	✓	WEL	4DCELL.WEL

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Table 6 (Cont'd.)

INPUT AND OUTPUT FILENAMES

Run Number	Rootname Modification	Date	Cell-by-Cell Flow File	Extension	Filename
4	D	05/23/91		OUT	4D0523.OUT
5	A	05/28/91		BAS	5A0528.BAS
5	A	05/28/91		BCF	5A0528.BCF
5	A	05/28/91		OC	5A0528.OC
5	A	05/28/91		SIP	5A0528.SIP
5	A	05/28/91		STR	5A0528.STR
5	A	05/28/91		WEL	5A0528.WEL
5	A	05/28/91	✓	BCF	5ACELL.BCF
5	A	05/28/91	✓	STR	5ACELL.STR
5	A	05/28/91	✓	WEL	5ACELL.WEL
5	A	05/28/91		OUT	5A0528.OUT
5	B	05/28/91		BAS	5B0528 BAS
5	B	05/28/91		BCF	5B0528.BCF
5	B	05/28/91		OC	5B0528.OC
5	B	05/28/91		SIP	5B0528 SIP
5	B	05/28/91		STR	5B0528.STR
5	B	05/28/91		WEL	5B0528.WEL
5	B	05/28/91	✓	BCF	5BCELL.BCF
5	B	05/28/91	✓	STR	5BCELL.STR
5	B	05/28/91	✓	WEL	5BCELL.WEL
5	B	05/28/91		OUT	5B0528.OUT
5	C	05/28/91		BAS	5C0528.BAS
5	C	05/28/91		BCF	5C0528.BCF
5	C	05/28/91		OC	5C0528.OC
5	C	05/28/91		SIP	5C0528.SIP
5	C	05/28/91		STR	5C0528.STR
5	C	05/28/91		WEL	5C0528.WEL
5	C	05/28/91	✓	BCF	5CCELL.BCF
5	C	05/28/91	✓	STR	5CCELL.STR
5	C	05/28/91	✓	WEL	5CCELL.WEL
5	C	05/28/91		OUT	5C0528.OUT

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Table 6 (Cont'd.)

INPUT AND OUTPUT FILENAMES

Run Number	Rootname Modification	Date	Cell-by-Cell Flow File	Extension	Filename
6	A	05/29/91		BAS	6A0529.BAS
6	A	05/29/91		BCF	6A0529.BCF
6	A	05/29/91		OC	6A0529.OC
6	A	05/29/91		SIP	6A0529 SIP
6	A	05/29/91		STR	6A0529.STR
6	A	05/29/91		WEL	6A0529.WEL
6	A	05/29/91	✓	BCF	6ACELL.BCF
6	A	05/29/91	✓	STR	6ACELL.STR
6	A	05/29/91	✓	WEL	6ACELL.WEL
6	A	05/29/91		OUT	6A0529 OUT
6	B	06/03/91		BAS	6B0603 BAS
6	B	06/03/91		BCF	6B0603.BCF
6	B	06/03/91		OC	6B0603.OC
6	B	06/03/91		SIP	6B0603 SIP
6	B	06/03/91		STR	6B0603.STR
6	B	06/03/91		WEL	6B0603.WEL
6	B	06/03/91	✓	BCF	6BCELL.BCF
6	B	06/03/91	✓	STR	6BCELL.STR
6	B	06/03/91	✓	WEL	6BCELL.WEL
6	B	06/03/91		OUT	6B0603.OUT
6	C	06/12/91		BAS	6C0612.BAS
6	C	06/12/91		BCF	6C0612.BCF
6	C	06/12/91		OC	6C0612.OC
6	C	06/12/91		SIP	6C0612.SIP
6	C	06/12/91		STR	6C0612.STR
6	C	06/12/91		WEL	6C0612.WEL
6	C	06/12/91		OUT	6C0612.OUT
6	D	06/17/91		BAS	6D0617.BAS
6	D	06/17/91		BCF	6D0617.BCF
6	D	06/17/91		OC	6D0617.OC

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Table 6 (Cont'd.)

INPUT AND OUTPUT FILENAMES

Run Number	Rootname Modification	Date	Cell-by-Cell Flow File	Extension	Filename
6	D	06/17/91		SIP	6D0617 SIP
6	D	06/17/91		STR	6D0617.STR
6	D	06/17/91		WEL	6D0617.WEL
6	D	06/17/91	✓	BCF	6DCELL.BCF
6	D	06/17/91	✓	STR	6DCELL.STR
6	D	06/17/91	✓	WEL	6DCELL.WEL
6	D	06/17/91		OUT	6D0617.OUT
7	A	06/21/91		BAS	7A0621.BAS
7	A	06/21/91		BCF	7A0621.BCF
7	A	06/21/91		OC	7A0621 OC
7	A	06/21/91		SIP	7A0621 SIP
7	A	06/21/91		RIV	7A0621.RIV
7	A	06/21/91		WEL	7A0621.WEL
7	A	06/21/91		GHB	7A0621.GHB
7	A	06/21/91	✓	BCF	7ACELL.BCF
7	A	06/21/91	✓	RIV	7ACELL.RIV
7	A	06/21/91	✓	WEL	7ACELL.WEL
7	A	06/21/91	✓	GHB	7ACELL GHB
7	A	06/21/91		OUT	7A0621.OUT
7	B	06/24/91		BAS	7B0624.BAS
7	B	06/24/91		BCF	7B0624.BCF
7	B	06/24/91		OC	7B0624.OC
7	B	06/24/91		SIP	7B0624.SIP
7	B	06/24/91		RIV	7B0624.RIV
7	B	06/24/91		WEL	7B0624.WEL
7	B	06/24/91		GHB	7B0624.GHB
7	B	06/24/91	✓	BCF	7BCELL.BCF
7	B	06/24/91	✓	RIV	7BCELL.RIV
7	B	06/24/91	✓	WEL	7BCELL.WEL
7	B	06/24/91	✓	GHB	7BCELL.GHB
7	B	06/24/91		OUT	7B0624.OUT

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Table 6 (Cont'd.)

INPUT AND OUTPUT FILENAMES

Run Number	Rootname Modification	Date	Cell-by-Cell Flow File	Extension	Filename
7	C	06/25/91		BAS	7C0625.BAS
7	C	06/25/91		BCF	7C0625 BCF
7	C	06/25/91		OC	7C0625.OC
7	C	06/25/91		SIP	7C0625.SIP
7	C	06/25/91		RIV	7C0625.RIV
7	C	06/25/91		WEL	7C0625.WEL
7	C	06/25/91		GHB	7C0625.GHB
7	C	06/25/91	✓	BCF	7CCELL.BCF
7	C	06/25/91	✓	RIV	7CCELL.RIV
7	C	06/25/91	✓	WEL	7CCELL.WEL
7	C	06/25/91	✓	GHB	7CCELL.GHB
7	C	06/25/91		OUT	7C0625.OUT
7	D	06/28/91		BAS	7D0628.BAS
7	D	06/28/91		BCF	7D0628.BCF
7	D	06/28/91		OC	7D0628.OC
7	D	06/28/91		SIP	7D0628.SIP
7	D	06/28/91		RIV	7D0628.RIV
7	D	06/28/91		WEL	7D0628.WEL
7	D	06/28/91		GHB	7D0628.GHB
7	D	06/28/91	✓	BCF	7DCELL.BCF
7	D	06/28/91	✓	RIV	7DCELL.RIV
7	D	06/28/91	✓	WEL	7DCELL.WEL
7	D	06/28/91	✓	GHB	7DCELL.GHB
7	D	06/28/91		OUT	7D0628.OUT

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Table 7

SUMMARY OF CALIBRATION RUNS

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
1A0411 1B0412 1C0416 1D0417	1) To eliminate dry cells. 2) To produce convergence before 150 iterations.	1) Initial conditions described in Section 5 were used. 2) Corrections were made to the input files.	1) Simulation converged for 1D0417. 2) Simulated water elevations were between 60 and 150 feet higher than the observed water elevations.
2A0422 2B0423 2C0424 2D0424 2E0424	1) To match the computed heads with the observed heads.	1) Input files of 1D0417 were initially used. 2) Various combinations of hydraulic conductivity and transmissivity values were used. 3) Some recharge values for the stream segments used in the STR input file were decreased.	1) Simulation converged for all runs. 2) The simulated groundwater flow patterns compared well with observed flow patterns. 3) Simulated water elevations did not change significantly from those simulated for 1D0417.
3A0425 3B0502	1) To match the computed heads with the observed heads.	1) Input files of 2E0424 were initially used. 2) Various combinations of hydraulic conductivity and transmissivity values were used. 3) The constant-head boundary conditions for the eastern and western boundaries were replaced with general-head boundary conditions.	1) Simulation did not converge after 150 iterations due to the boundary condition changes made to the eastern and western boundaries in 3B0502.
4A0521 4B0522 4C0523 4D0522	4) To match the computed heads with the observed heads. 2) To test the boundary conditions for the eastern and western modeling boundaries.	1) Input files of 3A0425 were initially used. 2) The constant-head conditions for the eastern and western boundaries of the modeling area were replaced with several different sets of constant recharge values.	1) Simulations did not converge after 150 iterations for any of the new boundary conditions used for the eastern and western boundaries.
5A0528 5B0528 5C0528	1) To match the computed heads with the observed heads.	1) Input files of 3A0425 were initially used. 2) Various combinations of hydraulic conductivity and transmissivity values were used.	1) Simulation converged for all runs. 2) Water elevations for layer 2 in the southern portion of the modeling area between the Loma Linda and San Jacinto faults decreased drastically.
6A0529 6B0603 6C0617 6D0617	1) To match the computed heads with the observed heads.	1) Input files of 5A0528 were initially used. 2) Various combinations of hydraulic conductivity and transmissivity values were used, including increasing the values by 50% and replacing them with those used by Hardt and Hutchinson (1980).	1) Simulations did not converge after 150 iterations for any of the runs.

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Table 7 (Cont'd.)

SUMMARY OF CALIBRATION RUNS

Runs	Objective(s)	Input Files Used and Revisions	Summary of Results
7A0621 7B0624 7C0625 7D0628	1) To match the computed heads with the observed heads.	1) Input files of 5A0528 were initially used. 2) The STR input file was replaced with the RIV and GHB input files (described in Section 5.4). 3) Various combinations of hydraulic conductivity and transmissivity values were used, including replacing them with those used by Hardt and Hutchinson (1980).	1) Simulation converged for 7D0628. 2) Many cells surrounding Shandin Hills in layer 1 went dry. 3) Except for the area containing the dry cells for layer 1, the simulated groundwater flow patterns compared well with observed flow patterns.

1.7 FUTURE MODIFICATIONS TO STEADY-STATE MODEL

Several modifications are anticipated for the future calibration runs of the steady-state model.

- The constant-head boundary conditions that exist for the eastern and western boundaries of the model area would be changed to general-head boundary conditions. The flows across the eastern and western boundaries that are created by this condition would be compared to corresponding flows calculated by other model studies of the area.

- An evapotranspiration rate of approximately 16,000 acre-ft/yr (Hardt and Freckleton, 1987) would be added to the model area.

- It has been estimated that where the depth to water in the upper aquifer is greater than 10 ft below land surface, approximately 30% of the total pumpage is recharged to this aquifer as sewage and irrigation-return water (Hardt and Hutchinson, 1980). This recharge would be incorporated into the model by reducing the pumping rates for each well by 30%.

1.8 RECOMMENDATIONS FOR FUTURE MODELING

At this time, the conceptual model has been developed, input data for the preliminary steady-state model have been prepared, and calibration of the preliminary groundwater flow model is nearly complete. The following model stages remain: calibration of the transient flow model; verification of the flow model; simulation of several remediation pumping schemes; and completion of the sensitivity analyses. All of these model stages will be performed with the project flow model. Three additional model stages would be needed to assess groundwater flow patterns, velocities, and TCE and PCE transport.

An important addition to the model stages would be the application of MODPATH (a three-dimensional particle-tracking program used in conjunction with MODFLOW). This proposed model stage is highly recommended by EPA technical support staff. MODPATH calculates the path of a particle in a steady-state, three-dimensional flow field over time (groundwater velocities). MODPATH uses the heads and cell-by-cell flows from MODFLOW and the porosity of the aquifer medium to move each particle through the flow field. If a particle location is specified, MODPATH can calculate the location of the particle at any time (Pollock, 1990)

Use of MODPATH in conjunction with MODFLOW would allow groundwater velocities and streamlines to be calculated. Imaginary particles would be located in various areas of the plume and could be traced back to the approximate source area. This analysis could facilitate locating potential source area(s), delineating the present plume area, and placing proposed extraction wells.

A second proposed model stage, which employs either a three-dimensional numerical or analytical solute-transport model, would be useful to assess the groundwater flow patterns and velocities and contaminant-transport behavior of TCE and PCE. A three-dimensional solute-transport model would be used to characterize the behavior of TCE and PCE in the groundwater. Also, the model would be used to characterize the movement of a conservative constituent such as boron or chloride. The velocities of the conservative constituent could be compared to the groundwater velocities calculated by MODPATH. In addition, it may be possible to characterize the different aquifer zones through tracer studies of naturally occurring constituents. A solute-transport model would probably give a more realistic picture of particle migration than MODPATH, since dispersion and retardation would be taken into consideration.

The third proposed model stage would involve a two- or three-dimensional analytical groundwater flow model. This model stage is highly recommended if the second additional model stage was not chosen. The groundwater velocities calculated from MODPATH would be compared to those calculated by the analytical model. Possible anomalies of the groundwater flow system produced by MODFLOW and MODPATH could be identified. The above second and third proposed model stages are not included in the RI/FS Work Plan scope.

1.9 SUMMARY

The preliminary model study during Phase I included collecting existing available geologic data and well information, developing a conceptual model, and preparing the steady-state groundwater flow model. Although a large quantity of data were gathered, most were not of sufficient detail for effective use during a RI/FS. This information was originally collected for purposes other than contaminant assessment and remedial evaluation (i.e., water supply locations and quantities versus contaminant plume delineation). For example, the encountered geology noted in various drillers' logs was not described in a standard or consistent format. This made it difficult to reliably correlate the geology from one well to the next. Though six geophysical logs were discovered and evaluated, they provided information from only three distinct areas. Furthermore, even the four geophysical logs that were located within 2,000 feet on one another were very difficult to reliably correlate, as the alluvial depositional environment interpreted for the geology in this basin changes drastically within a few hundred feet.

Based on the samples taken from the existing water-supply wells, the extent of contamination and the downgradient edge of the plume could not be adequately differentiated. Most of the water-supply wells are perforated over large intervals in order to maximize water quantity; hence, the wells may be perforated throughout both contaminated and uncontaminated zones, resulting in substantially diluted contaminated groundwater. Therefore, sample results from the outer plume edge, as depicted on the City of San Bernardino plume map, may be wells which actually contain significant quantities of TCE and PCE at specific depths where none was detected. In other words, the actual extent of contaminated groundwater could be significantly different than currently surmised.

Furthermore, TCE and PCE, characterized as dense non-aqueous phase liquids (DNAPLS), could be present below the screened depths of the wells. DNAPLS (and in some cases solvents in aqueous phase) tend to migrate downward through an aquifer until they intercept an impermeable barrier and then move laterally. Since most of the water-supply wells within the Newmark site are not completed to impermeable bedrock. It is feasible that samples collected from these wells are not reflective of the true groundwater quality of the local area.

After the geologic data and well information were collected and compiled, several geologic cross-sections and structure maps were constructed and a conceptual model was developed. Geologic and hydrogeologic interpretations were then grouped into several data sets. Those data sets required for input into the project flow model are as follows:

- The bottom elevations of model layer 1 (upper aquifer)
- The top elevations of model layer 2 (lower aquifer), the initial water elevations for layer 1
- The initial water elevations for layer 2
- Boundary conditions -- no-flow, constant-head and general-head boundaries
- Surface-water conditions for the percolation basins and streams
- Inflow and outflow conditions for canyon and stream recharge areas and stream discharge areas
- Well pumpage
- Vertical leakance values for the middle confining clay unit

These data sets were prepared and formatted into 6 to 8 input files that are read by MODFLOW:

- Basic (BAS)
- Block-centered Flow (BCF)
- Output Control (OC)
- Strongly Implicit Procedure (SIP)
- Well (WEL)
- Streamflow routing (STR)
- General-head Boundary (GHB)
- River (RIV)

After 29 calibration runs, the original input files have undergone several revisions; each revision contributing to the understanding of the hydrogeologic system. The last completed calibration run (*7D0628*) has consisted of the original input files with the following changes:

- Transmissivities and hydraulic conductivities we've interpreted from initial analysis of recent water supply tests and historical data were replaced with those used by Hardt and Hutchinson (1980). These changes are located in the BCF input file; and

- The STR input file was replaced with the RIV and GHB input files to provide greater flexibility. The lateral area of the stream alluvium was widened and all percolation basins were modified so that all incoming surface water recharged the groundwater.

During the preparation and calibration process of the preliminary model, several geologic and hydrogeologic interpretations pertaining to the model area, were formed. It has been concluded that the lower aquifer south of Shandin Hills is of the same coarse material as the single aquifer existing north of Shandin Hills. Furthermore, this aquifer material is characterized by very high hydraulic conductivities (particularly the aquifer material surrounding Shandin Hills).

1.10 REFERENCES

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